

Ethernet based online process monitoring and controlling of a plant having RS-232 or RS-485 equipment

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The most popular and traditional communication link among the plant equipment is either RS-232 or RS-485. Generally, these links are extended to a plant computer for Supervisory Control And Data Acquisition (SCADA) purpose. There are many benefits in upgrading such a system into an Ethernet enabled system (Reference 1). One can not only increase the number of devices that can be interfaced to a single computer, but also access the plant devices from multiple computers that are geographically distributed. The plant computer's bus structures, such as ISA or PCI, and the availability of RS- 232 or USB ports will not be a constraint in increasing the number of serial port devices, once they are Ethernet enabled.

A common method for Ethernet enabling is to replace the existing RS-232 / RS-485 equipment with those having built-in Ethernet. This is an expensive and time-consuming solution. A compromised solution will be to connect the plant computer to the LAN (Local Area Network). This method can help in the remote viewing of the plant data but online monitoring and controlling will not be possible. Further, if the plant computer fails, the remote monitoring will not be possible. A better technique in terms of cost, time-to-implement, redundancy and reliability will be to use a multi-channel **Serial Device Server (SDS)**. The SDS accepts number of RS- 232/RS- 485 based devices and provides one Ethernet port through which they all can be accessed.

The plant considered here is an autoclave, which is used for the fabrication of airworthy advanced composites structures. Autoclave is a pressure vessel with provision to load materials into it and subject them to a rate-controlled environment of thermal and pressure cycle. Autoclaves are used in variety of process industries but those used for the processing of advanced composites structures have to meet stringent control requirements. The autoclave control system consists of Programmable Logic Controller (PLC), Digital Recorder, Advanced Process controllers etc. All these equipment have either RS- 232 or RS- 485 communication link. More details about the computer controlled autoclave system for composites fabrication is available in the reference-2.

This paper presents the work done in Ethernet enabling the autoclave control system consisting of RS-232 / RS-485 equipment using a multiport Serial Device Server (SDS). As an added advantage of networking the serial devices, a Master / Slave computer controlled system has been realized. Further, the autoclave system can be monitored and controlled online through any authorized and networked computer. The method presented here works well even if the plant computers fail. This paper also presents the communication aspects of the software developed and proposes a networking scheme with complete redundancy for a larger autoclave.

Serial Device Server (SDS)

Serial Device Server network enable traditional RS-232 / RS- 485 devices. It provides multiple serial ports at one end and the Ethernet port on the other end. It consist of a processor, buffer memory, real-time OS, level shifters and TCP/IP protocol stacks and bi-directionally translate the data between RS-232 and Ethernet formats. The SDS used for upgrading the autoclave control system is 'MOXA® NPort 5410'.

The MOXA® NPort 5410 SDS has four isolated RS- 232 ports. The communication parameters of these ports such as, port identity, transmission speed, flow control mode, number of data bits, number of stop bits and parity type can be configured independently to match the respective plant equipment. Number of SDS can exist together in a network segment. Each SDS has to be programmed with a unique IP address, which can be assigned by the user or obtained automatically from the server. The SDS can be configured using Windows utility, Telnet, Web Browser or the built-in keys and display. It supports 10 or 100 Mbps Ethernet standard and provides versatile socket operation modes that include

TCP Serer, TCP Client and UDP. SDS transparently works with the existing serial communication application software through the Real COM mode driver. The driver installed on the host computer intercepts the data sent to the virtual COM ports of the host, packs it into a TCP/IP packet, and then redirects it through the hosts Ethernet card to the network. The SDS accepts the Ethernet frame, unpacks the TCP/IP packets and then transparently sends it to the appropriate serial device. More details about SDS are available in reference 3.

Autoclave control system

The major components of the autoclave control system are listed below:

- Central computer system and the application software
- Advanced PID controller to control the autoclave air or gas temperature
- Advanced PID controller to control the autoclave air or gas pressure
- Digital strip chart recorder to display, record and communicate various analog data such as air/gas temperature, job temperature at different locations, vacuum level in various parts etc.,
- PLC (Programmable Logic Controller) to sense the status of various I/O devices, ensure interlocking, sequencing, timing and logical controlling of autoclave devices and also to act as the digital I/O interface to the central computer

Figure 1 gives the schematic diagram of autoclave control system with the Serial Device Server.

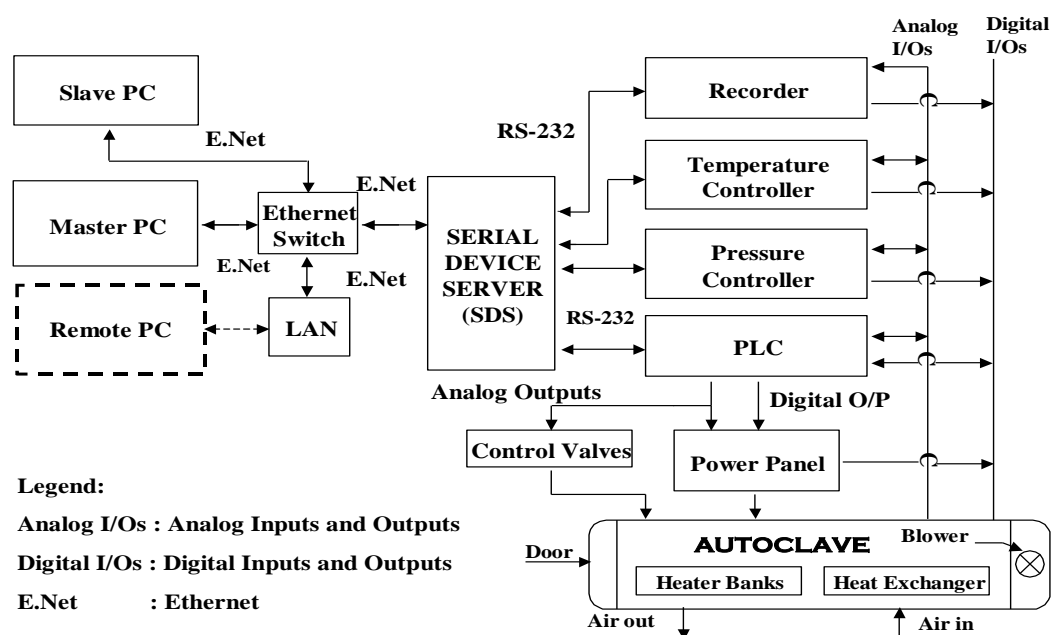


Figure -1 Autoclave control system with the Serial Device Server

Goal of the autoclave control system is to control the autoclave temperature, pressure and the job temperature as per the user programmed 'cure cycle'. A cure cycle specifies the rate of heating, dwell temperature, rate of cooling and similar parameters for pressure as a continuous function of time. User inputs the cure cycle to the computer, which then controls the autoclave by continuously downloading the set points as a function of time to the controllers. The computer acquires analog data from the recorder and uses it for controlling the job temperature, temperature gradient, archival and reporting. The computer acquires digital input data that represent status of limit switches, pressure switches, motors, heaters etc., from the PLC. It displays this data in a 'mimic' and also manages and reports alarms. It also initiates various activities like heat cycle, pressure cycle, shut down etc., by sending appropriate commands to the PLC. Autoclave has about 180 digital I/O (Input / Output) and about 40 analog I/O. Autoclave power panel controls heaters and various motors, prominent one being the Blower, which is responsible for circulating the hot air under pressure inside the autoclave. The peak power consumption of the autoclave is around 150 kW at 415 V AC. More details about the autoclave control system are available in reference –2.

Autoclave temperature and pressure are controlled by the general-purpose PID controllers, model 2404, manufactured by M/s. Eurotherm®. This controller has been configured to communicate using RS-232 standard and Modbus® protocol. The Digital strip chart recorder, model 4181M, manufactured by M/s. Eurotherm®, has also been configured to communicate using RS-232 standard and Modbus® protocol. The PLC model, 'Modicon® TSX premium' is manufactured by M/s. Schneider Electric Co. and provides a RS –485 link.

Implementation of SDS in the autoclave control system

The RS -232 links from the controllers, recorder and the PLC were connected to the SDS. The Ethernet port of the SDS was connected to the Ethernet switch. A computer designated as Master and another computer designated as Slave were connected to different ports of the Ethernet switch. A patch cable was also connected between the Ethernet switch and a LAN port to enable remote PC connection.

The SDS was configured using the Administration Suite software provided by the manufacturer with regard to the following parameters:

Basic settings that include server name and real time clock setting;
Network settings that include static, private IP address, Netmask, Gateway appropriate to the LAN;
Serial settings that include Baud rate, start bits, data bits, stop bits, parity and flow control;
Operation settings that include TCP server or client mode, UDP mode, Real COM mode, COM port mapping etc.,

Communication features of the (ACS) Autoclave Control Software

The ACS has been developed in-house using Visual C++® package. It supports all the standard SCADA features, in addition to controlling the job temperature through an intelligent algorithm. The communication aspects of the software are discussed here. Matching serial communication parameters are set in the serial device, SDS and the ACS software. The communication port of the serial device is given a COM number in the ACS. The same number is mapped to the respective device in the SDS administrative suit software. In addition, each serial device is given an address (usually a unique number) for device identification. Communication is initiated by the ACS at a programmed time interval. Communication is carried out in a time driven manner through multi-threading technique. Each thread has built in 'time-out' feature, where the thread is pre-empted in case of unusual delay. The software retries thrice to establish the communication before reporting a communication failure. Measured values of all the channels of the recorder are read for every five seconds. The recorder presents the data in IEEE floating point format along with the CRC (Cyclic Redundancy Check) code computed for that data stream. The ACS also computes the CRC of the received data stream and compares it with the received CRC value. The data stream is processed only when the computed CRC and the received CRC matches. The recorder data is decoded from the IEEE floating format (reference-4) and processed. The PLC has a built-in OPC (OLE for Process Control) server, which can be accessed through the OPC client software. A freely downloadable OPC client has been used in the autoclave application software to communicate with the PLC.

Autoclave Control Software differs slightly in the Slave computer and the Remote computer as compared to the Master computer. Both Master and Slave application software will be stored in both the plant computers. User assigns a computer as the Master computer by running the master application software from it. The cure cycle and other control parameters are programmed in the Master computer. Slave computer can be started after starting the Master computer. Once started, the slave software will request the Master to send the Programmed cure cycle, control parameters, process time and the acquired data. Thereafter, the Master will continue to send the acquired data at regular time intervals. If any control parameter is changed by the operator, the same will be communicated to the slave computer as well. If the slave computer does not receive the data from the master for a substantial time, it will start communicating with the SDS directly, without any user intervention. In addition to acquiring the data, the slave's software will also compute the set points and download it to the respective controller.

Networking scheme with redundancy for a larger autoclave:

To avoid single point failures and to cater for a larger autoclave having more number of serial devices a network scheme given in figure- 2 is proposed.

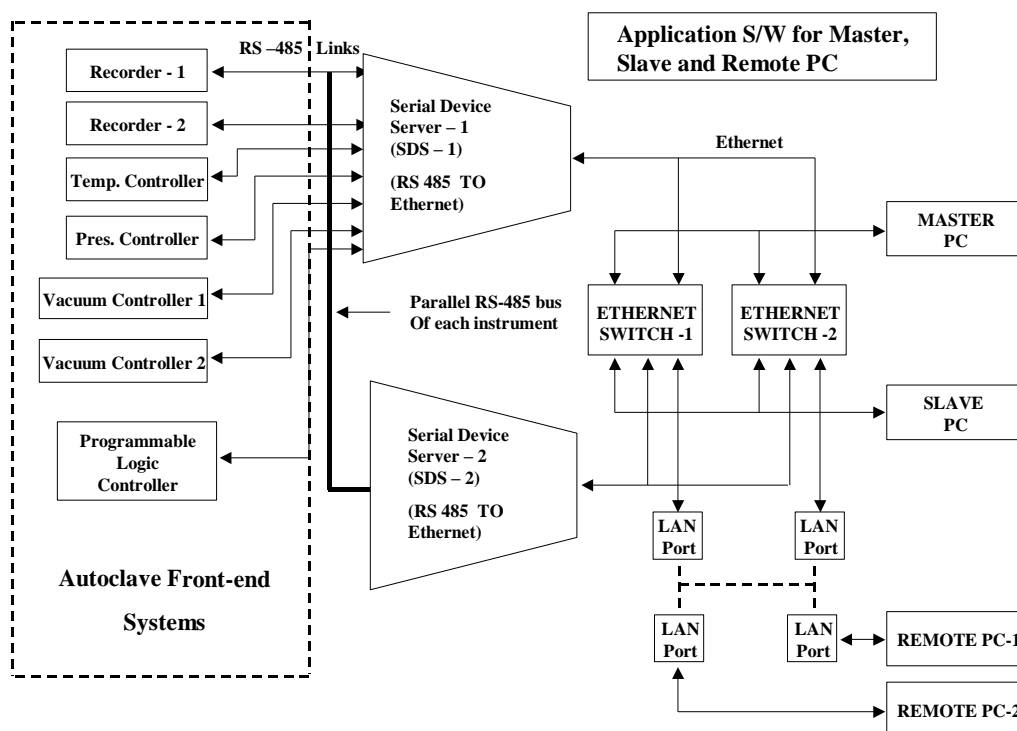


Figure -2 Proposed Network scheme with Redundancy for a larger autoclave

The system in figure-2 requires RS – 485 based serial devices as they permit multi-dropping. The RS – 485 port of each device is connected to the ports of two different SDS (SDS-1 and SDS – 2). The output port (Ethernet) of both the SDS is connected to the Ethernet switches. As a result, communication with the serial devices can be established through any combination of Ethernet switch and SDS. Both the Ethernet switches will also be connected to separate LAN ports through which a remotely located computer can access the plant. The proposed network scheme with redundancy for a larger autoclave is under development.

Conclusions:

The autoclave control system with SDS, as shown in the figure – 1 has been successfully implemented, tested and is being used regularly for the fabrication of airworthy advanced composites structures. The communication time-out and re-connect features of the software have been tested by intentionally changing the device identity number, communication parameters etc., Master computers failure has been simulated by removing its power, by disconnecting its network cable, and by intentionally putting the CPU in a loop. In all these cases the Slave computer has successfully taken over the control. The system is also used for remotely monitoring the plant.

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